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FOOD, DRINK AND EVOLUTION[1]

By Professor CHARLES T. BRUES

HARVARD UNIVERSITY

THE three primary animal instincts, to secure sustenance, to gain protection and to enjoy the opportunity of reproducing their kind, are related either individually or collectively to every biological problem, however narrow its scope. Although the impress of each of these necessities is to be found in the behavior and structure of every species, it is by no means evident to the same extent, nor alike at all periods of ontogeny. Reproduction is confined to a limited part of the life span even in the most primitive types of animals, and the period of reproductive activity is still more obviously restricted in the insects, where it becomes an attribute of only the final, unchanging imaginal stage. This stage must thus suddenly disclose all the adaptations of the sexually mature animal.

Protection from destructive agencies is on the other hand a constant necessity, common to all periods of the life span. It is, however, in part passive, as it may depend to a great extent upon bodily characteristics, not necessarily associated with specialized behavior.

The instinct to secure food is equally a constant necessity during post-embryonic growth, for only by its gratification can growth and development take place. Even more than reproductive activity the taking of food by animals is rhythmic, cyclical or interrupted by periods of varying length. Furthermore, food requirements in insects are proportionally much greater during the preparatory stages, when large reserves of fat are produced and stored within the body. Feeding is thus by no means a uniform or continuous process, but its association with the several stages is far more extended than is reproduction. Also, it is a purely active, never a passive, process, and in consequence we find that it has modified struc-

[1] Annual public address of the Entomological Society of America at its meeting in Richmond, Va., December 29, 1938.

ture and behavior even more profoundly than have the needs for protection.

The relations of insects to their food supply are very diverse and complex and taken together are unparalleled in any other group of living organisms. We have as yet made slow progress in unraveling the details and have been tempted to make many assumptions and generalizations which it must be admitted rest upon a rather flimsy basis. For this reason I feel that it behooves us as entomologists to take brief stock of our present knowledge concerning the food and feeding habits of insects as they appear to have influenced the course of insect evolution.

With reference to their choice of foods we may roughly group the insects into two categories, one of which includes herbivorous species, feeding directly on plants, and the other represented by those that are carnivorous, preying on other living animals or consuming those dead from other causes. The number of species in each group is approximately equal, but it is a striking fact that the great majority of the carnivorous forms depend upon other insects on which they are either predatory or parasitic. In this respect the insects are almost human, for the most important predatory and parasitic enemies of civilized man are other groups of men. Some of them accept and thrive upon the foliage and other tissues of numerous, often unrelated plants without evincing a pronounced preference for any particular kind. The number of such polyphagous species is large, but not so great as we once thought. Even some of our common grasshoppers restrict their feeding to one or at most to a very few species of plants. They may, however, under stress of hunger partake of many plants they would otherwise avoid, while other Orthoptera and even lepidopterous caterpillars may occasionally become cannibals. Such transgressions again are "almost human" and recall the behavior of mobs. They are of definite biological significance, for they show conclusively that the normally restricted diet of these insects is not a physiological necessity, since the unaccustomed substances cause neither digestive disturbances nor other metabolic derangement sufficient to interfere with normal growth and development.

Viewed in the light of our own appetites such a restricted dietary is utterly incomprehensible. We, as entomologists, are so accustomed to this peculiarity among many insect pests that we take it for granted and have shown little inclination to inquire into its evolutionary history.

Carnivorous insects exhibit many of the fundamental characteristics of their vegetarian relatives with reference to food, despite their more spectacular behavior. They are almost equally fastidious in confining themselves to diets as circumscribed as those affected by vegetarian species. Thus, certain ground beetles of several related genera restrict their food to snails. Lady-beetles consume great numbers of aphids and scale insects either generally or with great specificity. The solitary wasps store their nests with spiders and insects of all kinds, but we find, generally, that each species limits its provisioning to members of a single family or still more closely restricts its choice, sometimes, to a single species of prey. Such behavior is again difficult to reconcile with our own human appetites.

Parasitic insects present undoubtedly the most striking series of highly specialized food habits to be found in the whole animal kingdom, and their behavior is modified for several reasons. The vast majority, known as entomophagous or insect-eating, parasites, present a picture that is fundamentally different from the more conventional types of parasitism among other organisms. They are members of the holometabolous orders of insects in which it is almost invariably only the preparatory stages that dispense with a free-living existence. One result of this dual mode of life is the acquisition of totally different food-habits by the larval and imaginal stages of the insects concerned. This is paralleled, but to a far lesser degree, by the nectar-loving butterfly that suddenly discards the carrots or cabbage that nurtured it as a caterpillar. Such vagaries should not surprise us, as they are quite in keeping with our own personal habits when we feed our offspring on milk and spinach and deny them the liqueurs and lobster that we smugly reserve for the age of discretion. Nevertheless, this proved to be an innovation for insects as it initiated the development of the many remarkable modifications which now follow independent lines of evolution in the larval and imaginal stages. This condition reaches its highest development among parasitic insects. The free-living imagines are morphologically of quite ordinary structure, but the female is endowed with very highly adaptive and complex instincts associated with host-selection and oviposition. The larvae on the other hand commonly show unusual physiological, morphological and behavioristic peculiarities that enable them to develop successfully within the eggs or bodies of the many diverse insects on which they are parasitic. Individual species are narrowly restricted in the selection of host insects, even more regularly so than the free-living vegetarian and predatory types.

We have already mentioned the fact that one of the most extraordinary features of this horde of entomophagous parasites is their selection almost exclusively of other insects as hosts and that the same is true of predatory insects. For this reason the insects are a much more self-contained series of organisms than any other group of animals. That is to say, the balance of nature which determines the fluctuations of organic populations is among the insects dependent

to a large extent upon the abundance and activities of other insects.

It is perfectly obvious from the foregoing very inadequate summary that food and food-selection play a very important part in the present economy of the insects as a whole. Thus we may readily surmise *a priori* that their evolution and diversification through the ages have been determined in great measure by the changes and specializations that have established the complex picture just presented.

We may now inquire to what extent the evolution of insects has been directed or modified by the persistence of stabilized food habits and by the acquisition of new methods of securing sustenance in a living world that has itself undergone vast changes.

Since vegetarian insects are at the present time the mainstay of the entire series it is natural to suppose that this type was the first to appear on the earth, but this appears dubious when we examine it critically. The present vegetarian insects depend mainly on the seed plants, and these were not in existence till long after insects had become highly differentiated. Moreover, specialized predators, like the dragon-flies and mantids, are included among the early arrivals, quite contemporaneous with the precursors of vegetarian types.

The obvious conclusion to be drawn from these facts is that the several types of food habits have persisted without change for very long geological periods. This may be most naturally attributed to physiological or anatomical necessity. That is to say, to assume that animal foods are the only ones suitable for the proper nutrition, growth and reproduction of carnivorous insects and that plant foods are similarly required by vegetarian insects. Two plausible reasons for such an assumption readily come to mind. The restriction may be functional or physiological, depending upon the ability of the animals to utilize the materials which they eat. Or it may, on the other hand, depend upon the morphology of the mouthparts and digestive system or upon structures accessory to the feeding process such as prehensile legs or unusually delicate sense organs. Such mechanistic explanations do not suffice, so as a third alternative we may blame it on the pure cussedness of the "critters" and call it blind instinct. We shall have to leave this question in abeyance till we have considered some other aspects of the problem.

It is quite axiomatic that there is usually a high correlation between form and function in animals, meaning form in a wide sense. An extension of this idea to behavior, habits or bionomics as an integral part of "function" is justified, partly because of the necessarily loose way that these terms must be applied to the activities of animals. Also, it is impossible to find any discontinuity as we pass gradually from a purely physico-chemical type of functional activity to the complex train of events involved in the search, capture, mastication, digestion and final utilization of food by a predatory insect. Such associations are the essence of the division of labor between the parts of the animal body, and they lose their true significance once we attempt to deal with them as independent or even separable units. Nevertheless, we shall proceed to do this very thing, as there seems to be no other approach. We perceive everywhere niceties of structure that are obviously suited to the food-habits of their possessors. The asymmetrical grinding mandibles of a grasshopper are better fitted for chewing foliage than for tearing flesh, although they may draw blood from our finger if it is offered to them. The composite sucking jaws of an ant-lion suit their purpose admirably, but they would make little headway if their owner elected to eat a tasty bit of spinach. The scissor-like mandibles of the worker amazon ant are fine for a formicine pogrom, but render the ants useless in their own nursery as they can not even pick up their babies without danger of inflicting mortal injury.

Without prolonging this familiar inventory, we will agree that such profound modifications are important factors in limiting the choice of food.

Nevertheless, if we should continue to enumerate further such similar structural adaptations of mouthparts we would reach the point where the correlation was far less patent. Then we could not honestly say that a transition, for example, from predatism to vegetarianism would entail any mechanical difficulties.

Indeed, some of the most interesting and instructive evidence bearing on the evolution of food habits is furnished by the sporadic appearance of aberrant diets in insects belonging to groups that are otherwise homogeneous in this respect. The acquisition of carnivorous habits by butterflies or moths and the occurrence of a few vegetarian members among the enormous series of parasitic chalcid flies are examples of this phenomenon.

Clear-cut examples are to be found which show that there have occurred occasionally shifts in food habits whereby changes comparable to structural mutations have resulted in the appearance of vegetarian habits in a purely carnivorous group or *vice versa*. Likewise between the four types, phytophagy, predatism, parasitism and saprophagy, similar shifts may be noted. One of these relates to the very obnoxious Mexican bean beetle.

It is well known that the lady-birds or coccinellid beetles form an almost uniformly predatory group. They spend their entire developmental and adult life gobbling up helpless aphids or scale insects and hence represent the acme of virtue to the economic entomologist. To him the bean beetle is *persona non grata* for the subfamily Epilachninae into which she was born

gave up the murderous habits of their ancestors and became gentle vegetarians many millions of years before it became a fad in America to visit Battle Creek for this purpose.

Together with a number of similarly degraded relatives the bean beetle forms the cosmopolitan genus Epilachna, so named because it has a fuzzy back in the place of the hairy chest that adorns the real meat-eating he-beetles. For this reason the term lady-bird is particularly appropriate. A few distant cousins forming two other genera are equally disreputable vegetarians with specific food plants. A second species, *Epilachna borealis,* is common in eastern North America, feeding on the foliage of our native wild cucumber and also mutilating cultivated squash and pumpkin vines. We have thus in our region two species, each with sharply restricted food plants. In Europe two species feed on cucurbits, usually on native palearctic species, and one of these may on occasion attack potato foliage when its preferred food plants are absent, but no European species are known to feed on legumes. Further eastward, from India to Japan, Malaya and Australia a common oriental species is often a pest of potatoes and may be frequently found feeding on other solanums and related genera, while a Japanese species feeds on both Cucurbitaceae and Solanaceae. In South America two species eat cucurbits, but none are known to eat solanums. Finally in Africa no less than five species attack cotton, a malvaceous plant that is never known to harbor the beetles on other continents except in one or two isolated cases that have been reported.

From this complicated situation we may draw several inferences. The integration of food plants and Epilachnas throughout their entire range demonstrates quite conclusively a genetic relationship in their diets traceable to a common origin of their vegetarian habits. Since that time, which was probably at least well back in the Tertiary, the genus has attained its present cosmopolitan distribution, has undergone differentiation into numerous species and split off two minor vegetarian genera. On the basis of related food-plants in adjacent areas we might even trace its migrations in space and time just as paleontologists have done for certain mammals on the basis of their fossil remains. From the foregoing it is evident that phytophagy appeared full-blown, like a structural mutation, and that the insects became addicted to particular plants which they were loath to leave even during the long period required for speciation to the present level. Other coccinellids are known to feed occasionally on foliage, pollen or fungi although retaining their primary predatory habits. The fixation of such an aberration would produce the kind of sudden change that we have just described.

Changes from parasitic to vegetarian habits are well illustrated by a number of chalcid flies of the order Hymenoptera. The members of this enormous group of minute insects are entirely parasitic, except for scattered genera or species that have turned to plants for food. In such cases this involves changed instincts in the adult wasps and an utterly strange environment for the larva, which becomes an internal feeder within the seeds or other plant tissues, sometimes with the production of galls or malformations in the host plant. Contrary to the condition in the lady-beetles, the food of the adult chalcid-fly undergoes no change. Phytophagous habits have appeared in at least six of the fifteen families that compose this group, and they are so scattered that no one can question their independent origin. A quite recent inception is indicated in some cases where the vegetarian forms are not even generically distinct from the parasitic ones.

Here again we encounter fundamental changes in larval food and imaginal instinct, but no correlated structural modifications. As a matter of fact the changes are occasionally not so great as they appear at first sight when we come to examine them closely. For example, in the Eurytomidae, the primitive members of the family are parasites of gall-making insects, so that the mother wasp must lay her eggs within the galls in order to reach the host larva that is enclosed therein. Some of the derived forms, like the abundant and destructive species of Harmolita, still lay their eggs within the tissues of grains and other grasses, but the larva is a vegetable feeder and, what is most remarkable, its larva also produces gall-like swellings of the grass-culms within which it feeds. It is thus in the same sort of immediate environment as its parasitic forbears, but is eating the plant directly.

We have mentioned the great age of the derived vegetarian habits of the bean-beetle and we could readily present evidence to show the antiquity of other similar shifts from one method of feeding to another that have taken place.

We have already referred to the development of quite independent lines of evolution in the larvae of insects without correlated modifications in the reproductive stage. This condition is involved to some extent in shifts from one type of food habits to another, but we have seen that these do not necessarily involve a high correlation between form and function, but that rather the reverse is true.

However, slow-moving, non-aggressive larvae tend to be vegetarian and the opposite holds for predatory forms. Glaring exceptions come to mind, such as the highly degenerate apodous, blind and almost jawless larvae of syrphid Diptera and certain predatory gall-midges that suck the juices of aphids for a living.

If we turn from these poor moronic maggots to the trim aphis-lion, enjoying the same diet, we are confronted with the very quintessence of adaptation: good

vision, strong active legs, jaws of marvelously complicated and appropriate form and all in all a creature that looks and acts the part. "Ain't Nature wonderful" when we contemplate the inscrutable tenacity of purpose that enables all these creatures to keep "off relief" and successfully cope with their environment?

This leads us to another phase of the food problem among insects that has had a profound influence on the evolution of many vegetarian groups, especially among the social insects. I now refer to those that have established symbiotic relations with, and cultivated certain fungi and micro-organisms of several types. In this way they have been able to exploit their environment by fostering the growth of plants for food just as civilized man has done through the development of a farmer class. But we must not apply this comparison too closely, for the similarity is quite superficial. They have not bartered away their own products, wishing to acquire others in their place, but have lived the self-contained life that is characteristically theirs as insects. Consequently, they have been able to maintain themselves in a biocoenosis that excludes many undesirable meddlers and parasites.

The mycetophagous food-habits of the ambrosia beetles and the fungus-growing ants and termites are familiar to all of us. Their origin is obscure, but we may be reasonably certain that they arose through chance associations with fungi growing in the wood or other vegetable material where the ancestors of these insects fed. During the course of time, at least some of the fungi have undergone marked evolutionary changes which set them off from their non-symbiotic relatives. At the same time various structures have been developed by the insects like the bristly heads of the ambrosia beetles and instincts like the leaf-cutter ant-queen, who takes a neat little packet of the fungus spawn along when she goes in search of a new home. The precious treasure is stuck in her cheek like a quid of tobacco to be later erupted as the nucleus for the garden that is destined to nourish her future household. Here we see that in spite of the fundamental changes in food habits only slight structural or instinctive modifications are required to render the new system at once self-perpetuating.

Concerning the symbiotic relations of termites to the fauna of highly specialized flagellate Protozoa that inhabit the alimentary tract of these insects we have quite a complete picture. The ability of these symbionts to digest cellulose renders them at once absolutely necessary in the economy of the wood-consuming termites, by a direct trophic relationship. This is perpetuated by the unhygienic habit prevalent among socially minded insects of transferring food from one to another just as the communal lolly-pop insures the propagation of mumps and measles. The great age of this association is shown by the large number of termite protozoans and their differentiation into many taxonomic groups.

Concerning the intracellular symbionts that occur in many insects, we have as yet insufficient knowledge to do much more than speculate about their probable origin and present importance to the insects that harbor them.

From their irregular distribution among insects and the occasional occurrence of more than one species of symbiont in a single insect we are safe in assuming that symbionticism is of multiple origin. That they have played a part in guiding the evolution of food-habits in insects seems quite certain.

Another interesting corollary which greatly strengthens the conclusions we have reached concerning the great age of the numerous sorts of food habits may be derived from an entirely independent source. Over the course of many years I have devoted some time to purely taxonomic studies of certain Tertiary insects, especially those in Baltic amber of Oligocene age. Gradually the impression has developed that the insect fauna at that remote period, at least so far as certain groups are concerned, was not only as extensive and varied as the living one, but that many of the complex associations like myrmecophily and parasitism existed in the form that we encounter them to-day.

What in brief are the general conclusions that may be drawn from the material I have endeavored to parcel out in more or less independent categories? Has the evolution of insects been influenced and guided to an exceptional extent by their highly specialized food-habits? If so, can we point out any obvious reasons why they should differ from any other group of animals in this respect?

Many lines of structural evolution (if you will pardon the term) owe their origin and direction to the several types of food-habits. You may say this is putting the cart before the horse, but I think not, for it is the persistence of instinctive feeding habits over long periods that has provided a long, straight course for natural selection to act in the good old-fashioned way. Lest you throw me out as a nineteenth century biologist I hasten to repeat an earlier statement, that at least many of the shifts in food habits so conspicuous among insects have arisen as mutations in instinct that appear *de novo* and unexpectedly in perfectly serene ecological associations.

This is, I believe, the crux of the matter in that instinctive behavior, particularly with reference to food, is in insects of such paramount importance that its influence has transcended the cruder characteristics on which we can put our fingers and resolve into smaller particles under the microscope.

SCIENTIFIC EVENTS

THE FIRST HUNDRED YEARS OF PHOTOGRAPHY

AN exhibition illustrating the first hundred years of photography is on view at the Science Museum, South Kensington. The exhibition, according to the London *Times,* has been arranged by the museum in collaboration with the Royal Photographic Society. It is in three sections—the first consisting of early photographs and apparatus; the second of photographs, drawn from the society's collection, illustrating the history and development of pictorial photography down to the present; and the third of the commercial and scientific applications of photography.

In the third section are exhibits illustrating photo-engraving; various methods of color photography; the making of aerial surveys; and the use of photography in astronomy, mineralogy and electrical research. One case shows the improvement which has taken place in the sending of press photographs by cable across the Atlantic between the primitive results of 1927 (when a crude outline effect was achieved) and those of 1934, 1936 and 1939. Radiography also figures largely in this section, with a life-size human skeleton in one corner, a number of medical x-ray photographs and a miscellaneous and amusing collection of others, among which the head and spine of a fish—a species of ray—appear as most astonishing gnome-like monsters.

The *Times* states that exhibits in the early historical section illustrate the massive character of some of the early photographic apparatus. In particular there are a dark-room tent of about 1853 which had to be trundled around on a little two-wheeled pushcart, and a wet-plate outfit of 1855, standing on a tripod and large enough to have served, at need, as a quite sizable dovecote. The display also includes relics of the two men whose work made 1839 so greatly notable as the starting-point of modern photography, Daguerre and Fox Talbot. The Fox Talbot exhibits are drawn from the collection of his apparatus and photographs presented to the museum by his granddaughter, Miss M. T. Talbot, who was present at the opening of the exhibition. Some of the Fox Talbot prints, in spite of the publicity his work has had, are quite unfamiliar. D. O. Hill, Mrs. Cameron and Roger Fenton are other early photographers who are well represented.

FOREIGN MARKETS FOR MEDICINAL PRODUCTS OF THE UNITED STATES

ACCORDING to a world survey entitled "Foreign Markets for American Medicinal Products," made available by the Chemical Division of the Department of Commerce, the United States is one of the world's largest exporters of medicinal products, with shipments going forward regularly to more than a hundred foreign countries and trading areas.

Ten years ago when a similar survey was conducted, the United States was the largest exporter of medicinals and accounted for twenty per cent. of the import demand for such products. The present survey shows that although the United States exports approximately the same amount of medicinal products as ten years ago, it is now in the fourth place, following closely behind the United Kingdom and France. Germany is the principal exporter with sales almost double those of its nearest competitor.

The study deals at considerable length with the market for such products abroad, detailing the extent of the demand, local production, methods of distribution, advertising, branch factories, local packaging of imported bulk products, regulations, local preferences and other data.

An important point brought out is the changed character of the export trade of the United States. A decade ago practically all the medicinal and pharmaceutical products entering into foreign trade channels were packaged and ready for the ultimate consumer. Now many of these products are exported in bulk or in concentrated form, and are elaborated or packaged in the country of destination. Medicinal chemicals, for example, are elaborated and pressed into tablets or pills, and liquid products arriving in the country of destination in concentrated form are diluted with syrup, alcohol, water or other bulky ingredients before being packaged. These elaborating and packaging operations are carried out either in branch plants of the parent American companies or in local laboratories by license or other arrangements with the American brand or patent owners. This situation has been brought about by legislation enacted in various foreign countries, designed to stimulate the domestic medicinal and pharmaceutical industries.

A number of branch factories have been established abroad during the last ten years by American medicinal and pharmaceutical manufacturers, but the aggregate value of medicinal exports from the United States has been well maintained. Beginning with 1928 the value of exports of such products moved up somewhat, reaching a peak of $21,322,500 in 1929. Following that year foreign demand declined sharply and exports reached the low of $9,816,000 in 1933. From this low point, however, the total advanced steadily to approximate $18,000,000 in the years 1937 and 1938.

THE ROCHESTER ATHENAEUM AND MECHANICS INSTITUTE

THE Rochester Athenaeum and Mechanics Institute has been offered an anonymous gift of $400,000 provided that $600,000 additional can be raised for endowment purposes. The donor pointed out the long record of meritorious service of the institute to the

community as reason for the offer. The need for additional endowment is said to be one of the most pressing needs of the institute, the present endowment and trust funds amounting to $1,500,000 being entirely inadequate.

The following members of the Board of Directors have been appointed to a committee to make plans to raise the $600,000: James E. Gleason, *chairman;* Herbert W. Bromley, Dr. Albert K. Chapman, George H. Clark, M. Herbert Eisenhart, Dr. Mark Ellingson, Charles K. Flint, Edward A. Halbleib, Sol Heumann, P. Richard Jameson, Frank W. Moffett, Oscar H. Pieper, Herman Russell and Albert F. Sulzer.

Mr. Gleason in discussing the matter said that by the addition of a million dollars to the endowment funds a long step would be taken toward financial independence. Income from endowment has been steadily declining, and as tuition at the institute covers only about fifty per cent. of the cost of operation, the extension of its services makes additional support imperative.

The offer provides that the $600,000 to be raised must be secured by pledges on or before December 31, 1940. This does not necessarily mean that contributions must be made at once; pledges payable over periods as long as five years will be acceptable under the terms of the offer.

The institute was founded in 1829. It is Rochester's oldest educational institution, and during the past year has had a student body of nearly 3,400 day and evening school students. In the day school, instruction is offered to high-school and college graduates in the applied arts, publishing and printing, general home economics, food administration, retailing, photographic technology, construction, chemistry, electricity and mechanics. Over a hundred and forty courses are offered in the evening division for employed men and women. It has pioneered in the individualization of education, in the cooperative plan and in its counseling program.

BIOCHEMICAL RESEARCH AT THE UNIVERSITY OF PITTSBURGH

DR. ALEXANDER SILVERMAN, head of the department of chemistry in the University of Pittsburgh, announces the continuation of the biochemistry research project which has been subsidized by the Buhl Foundation of Pittsburgh. The personnel for 1939–40 follows: Max O. Schultze (Ph.D., University of Wisconsin), senior fellow; Herbert E. Longenecker (Ph.D., Pennsylvania State College), senior fellow; Theodore H. Clarke (Ph.D., University of Pittsburgh), senior fellow; Rade R. Musulin (Ph.D., University of Pittsburgh), senior fellow to September 1; Carl V. Smythe (Ph.D., University of California), senior fellow reporting September 1; Carter J. Harrer (B.S., University of Pittsburgh), research assistant; George W. Jack (B.S., Grove City College), research assistant; Mary L. Dodds (M.S., University of Pittsburgh), research assistant.

The grant covers researches on animal nutrition, tissue respiration and molecular structure. Dr. C. G. King, professor of biochemistry at the university, is director, and Dr. Gebhard Stegeman, professor of physical chemistry, is associate director.

To broaden the investigation which has been in progress for several years in the department of chemistry, additional funds have been provided by the Buhl Foundation, so that cooperative studies will be made with the departments of physics and biology and with the School of Medicine. The total available for the entire project is $60,000.

THE THIRD INTERNATIONAL CANCER CONGRESS

THE third International Cancer Congress will meet at Atlantic City, N. J., from September 11 to 15. The program, which has now been issued, includes papers on both the research and clinical phases of cancer, by authors from the United States, Canada, Mexico, South America and Europe. The following grouping has been adopted; Biophysics, Chairman Dr. Gioacchino Failla; Genetics, Chairman Dr. Clarence C. Little; Experimental Pathology, Chairman Dr. William H. Woglom; General Pathology, Chairman Dr. Milton C. Winternitz; Surgery, Chairman Frank H. Lahey; Diagnostic Roentgenology, Chairman Dr. John D. Camp; Therapeutic Radiology, Chairman Dr. Ursus V. Portmann; Statistics and Education, Chairman Dr. Burton T. Simpson, and finally a General Section which will be conducted by the president of the congress, Dr. Francis Carter Wood, for papers which arrive too late for classification under the different specialties.

A number of innovations have been made in planning the sessions of the congress. One of these is the appointment of a number of vice-chairmen, so that when a chairman must be absent from his section there will be available an assistant who is familiar with the program and the speakers. It has been ruled that all papers must be read at the time printed in the program.

The facilities for projection and demonstration will be unusually complete. Through the generosity of two large foreign instrument houses projection apparatus will be available for full-size radiographic films. There will be also, in a special room, a high-power projection apparatus for microscopic preparations, which will make it possible for groups interested in the finer details of a paper to study at leisure the microscopic lesions while the writer demonstrates his points. The usual lanterns and projectors for films also will be continuously available.

Each evening there will be lectures surveying special fields. The lecturers include the U. S. Surgeon-General, Dr. Thomas Parran, Jr., who will speak on "Cancer and the Public Health" on Wednesday evening after the president's dinner, and Professor James Ewing, who will close the meeting on Friday with an address on "Cancer, Present and Future," in which he will survey the accomplishments of the congress and express his opinions on methods for attacking the cancer situation in the next decade.

THE BICENTENARY OF THE ROYAL SWEDISH ACADEMY OF SCIENCES

THE preliminary program of general events for the Bicentenary Jubilee of the Royal Swedish Academy of Sciences, which meets in Stockholm from September 23 to 25, has been issued. The principal events are as follows:

Saturday, September 23

At 2: 30. Delegates and specially invited guests gather in the academy building at Frescati, where there will be arranged, in the assembly rooms, an exhibition of pictures, manuscripts and books, which will be demonstrated by the librarian of the academy.

After about an hour's stay in the academy building an opportunity will be given to visit the near-by Institute for Experimental Physical Research, the various sections of the Museum of Natural History, the Geological Survey of Sweden and the Bergius Botanical Garden.

At 6: 30. An informal dinner will take place at the restaurant Hasselbacken to welcome the delegates and specially invited guests.

Sunday, September 24

At 2: 00. Bicentenary festival in the Concert Hall of Stockholm in the presence of the King of Sweden and other members of the royal family. Further details will be given in a special program.

Monday, September 25

At 10: 00. Departure by steamer to Saltsjöbaden (alternatively by motor coaches at 11: 00).

At 12: 00. Demonstration of the Stockholm Observatory at Saltsjöbaden.

At 1: 00. Lunch at the Saltsjöbaden Grand Hotel or at some restaurant in Stockholm.

About 5: 00. The guests of the academy are invited to tea at the Royal Palace in Stockholm.

At 8: 00. The guests of the academy are invited to a gala performance at the Royal Opera House.

Those wishing to attend are advised to order in time hotel rooms for their stay in Stockholm from September 23 to 25. According to an agreement with the Organization Committee of the Academy the travel bureau "RESO," Stockholm, will undertake to provide hotel accommodation.

THE HUNDREDTH ANNIVERSARY OF THE BIRTH OF ROBERT HENRY THURSTON

THE hundredth anniversary of the birth of Robert Henry Thurston will be celebrated by Cornell University with the cooperation of the American Society of Mechanical Engineers on October 25.

The preliminary program follows:

Convocation in Bailey Hall, 10: 00 A.M.

Dr. Edmund Ezra Day, president of Cornell University, presiding.

Speakers

Dr. William Frederick Durand, professor of marine engineering, Cornell University, 1891–1904; emeritus professor of mechanical engineering, Stanford University; past president, American Society of Mechanical Engineers, and author of "Robert Henry Thurston: a Biography."

Dr. James Pickwell Adams, vice-president of Brown University.

Admiral Wilson Brown, superintendent of the United States Naval Academy.

Dr. Harvey N. Davis, president of the Stevens Institute of Technology and past president of the American Society of Mechanical Engineers.

Dean S. C. Hollister, College of Engineering, Cornell University.

During the afternoon, guests will have the opportunity to inspect the College of Engineering and meet informally with members of the faculty. There will be exhibits of Dr. Thurston's publications and of apparatus he designed.

The program gives the following sketch of Professor Thurston's life and work:

ROBERT HENRY THURSTON

October 25, 1839–October 25, 1903

Robert H. Thurston has been recognized as the leading mechanical engineer of his time and as the most influential educator in this field. While teaching at Annapolis, where the U. S. Navy transferred him after his period of active service in the Civil War, Thurston began to develop a plan for training engineers that would supplant the current vocational courses in mechanic arts. He put his plan into operation at Stevens Institute between 1871 and 1885, founding the first mechanical laboratory for purposes of instruction, assembling and at times inventing the necessary apparatus, and writing a pioneer manual, "The Materials of Engineering," for his students. In 1885 President Andrew D. White called Dr. Thurston to Cornell, where for 18 years he directed instruction in mechanical engineering, setting up a more comprehensive laboratory, writing additional textbooks, surrounding himself with able teachers and establishing educational standards and programs that set the pattern for modern engineering education. His biographer and former colleague at Cornell, Dr. W. F. Durand, has stated that his work at this university gave "to the College prestige and standing in the very front rank of the engineering schools of the country and of the world."

Throughout his career as a teacher and administrator, Dr. Thurston continued the practice of engineering and wrote voluminously for technical publications. He was one of the organizers and the first president of the Amer-

ican Society of Mechanical Engineers, serving for two terms; three times a vice-president of the American Association for the Advancement of Science, and a member of the American Society of Civil Engineers and of numerous other technical and academic organizations in this country and abroad. He also served on several important state and federal commissions.

Dr. Thurston was considered an authority on materials of construction, steam engines and boilers, and the history of engineering, as well as on the philosophy of education. His most widely known work, "A History of the Growth of the Steam Engine," published originally in 1878, is scheduled for republication this year as part of the celebration of the centennial of his birth.

Training engineers to meet the problems of the future was a subject of perennial interest to Dr. Thurston and will be the theme of the Anniversary Convocation. Thurston, the pioneer, proclaimed values and enunciated principles that have a bearing to-day, and the spirit of Thurston counsels boldness in grasping the immense opportunities of to-morrow.

RECENT DEATHS AND MEMORIALS

DR. LEWIS D. ROBERTS, professor of physical chemistry at the University of Southern California, died by suicide on August 3. He was in his fifty-sixth year.

DR. CLYDE MASON SHAW, professor emeritus of the College of Pharmacy at the University of Illinois, Chicago, died on August 5, at the age of seventy-one years.

DR. COOPER CURTICE, who retired as veternarian at the Bureau of Animal Industry of the U. S. Department of Agriculture in 1930, known for his work in the eradication of cattle ticks and cattle-tick fever, died on August 8, at the age of eighty-three years.

Nature reports the death on July 28 of Professor R. W. Reid, emeritus regius professor of anatomy in the University of Aberdeen; and of Scoresby Routledge, known for his investigations among the Akikuyu of East Africa and of the archeology and ethnology of Easter Island, on July 31, in his eightieth year.

ACCORDING to *Nature* a teak memorial seat to the late Sir William Perkin, the chemist, is to be unveiled and dedicated to the public at Sudbury, Middlesex, on August 12. The memorial will be outside a recreation ground, and opposite the site where Sir William's house and laboratory stood. The cost of the memorial has been met by public subscription.

SCIENTIFIC NOTES AND NEWS

DR. ROBERT A. MILLIKAN, of the California Institute of Technology, accompanied by Dr. H. Victor Neher and Dr. W. H. Pickering, sailed for Australia on August 16. They will engage in cosmic ray research in Australia, Tasmania, the East Indies, India and Egypt, returning in February, 1940.

THE Royal College of Physicians has made the following awards: the Baly Gold Medal to Dr. C. H. Best, professor of physiology in the University of Toronto, for his physiological researches; the Moxon Gold Medal to Sir Arthur Hurst, senior physician to Guy's Hospital, for his researches and observations in clinical medicine; the Weber-Parkes Medal and Prize to Sir Pendrill Varrier-Jones, founder and medical director of the Papworth Village Settlement, for his work on tuberculosis.

THE gold medal of the Royal Agricultural Society of England has been awarded to Sir George Stapledon, professor of agricultural botany at the University College of Wales at Aberystwyth and director of the Welsh Plant Breeding Station, "for his distinguished services to agriculture."

THE prize of the Senckenberg Foundation of the value of about 4,000 marks, which was established a hundred and seventy-five years ago, was awarded on the occasion of the twenty-fifth anniversary of the university at Frankfurt-a/M, to Dr. Ernst Ruska for his work with the electron microscope. The prize is awarded every three years to a German investigator for contributions to the advancement of medicine or science.

THE *Journal* of the American Medical Association reports that at the annual meeting of the Minnesota State Medical Association it was voted to present the distinguished service medal and scroll, awarded to members for special contributions to the work of the association, to the late Drs. William J. Mayo and Charles H. Mayo. Their photographs will be hung in the Medical School of the University of Minnesota.

DR. GEORGE H. FANCHER, professor of petroleum engineering at the University of Texas, has been elected a fellow of the International Institute of Petroleum, which has its headquarters in London.

THE University of Edinburgh has conferred the doctorate of laws on Dr. Francis H. A. Marshall, fellow of Christ's College, Cambridge, and reader in agricultural physiology in the University of Cambridge, in recognition of his work in the physiology of reproduction.

PROFESSOR LUIGO D'AMATO, director of the Medical Clinic of the University of Naples, has been made a senator of Italy.

DR. LAIGNEL-LAVASTINE, professor of the history of medicine at the University of Paris, has been elected president of the International Society of the History of Medicine.

THE *Experiment Station Record* states that Dr. E. C. Van Dyke, professor of entomology at the University of California, retired with the title emeritus on July 1 after twenty-six years of service. He will be succeeded by Dr. E. O. Essig, whose work will be taken by Dr. Guy F. MacLeod, professor of economic entomology at Cornell University. Drs. E. Gordon Linsley and Robert L. Usinger have been added to the staff as instructors in entomology, the former to be stationed at Berkeley and the latter at Davis.

DR. RICHARD W. JACKSON has been promoted to an associate professorship of biochemistry at the Cornell University Medical College, New York City.

DR. ALFRED L. ANDERSON, acting head of the department of geology at the University of Idaho, has been appointed assistant professor of geology at Cornell University. He will give lectures on economic geology.

DR. CHARLES H. NORRIS has been appointed instructor in biology at the University of Colorado.

DR. NOËL FIESSINGER, professor of experimental pathology at the University of Paris and co-editor with his father, Dr. Charles Fiessinger, of the *Journal des Praticiens,* has been nominated professor of clinical medicine in succession to Professor Carnot, who is retiring on reaching the age limit.

DR. W. G. BARNARD, consultant histologist of the Public Health Department of the London County Council, has been appointed from October 1 to the chair of pathology of the University of London, tenable at St. Thomas's Hospital Medical School.

THE John Lucas Walker Studentship of the University of London for original research in pathology, of the value of £300 a year for three years, has been awarded to J. C. Colbeck.

DR. F. WOOD JONES, professor of anatomy at the University of Manchester, will retire at the end of the Michaelmas term.

BRAYTON EDDY, lecturer on entomology, was recently appointed administrator of the Office of Entomology and Plant Industry for the State of Rhode Island.

ROBERT J. CHEATHAM, now in charge of cotton utilization research in the Bureau of Agricultural Economics of the U. S. Department of Agriculture, has been made head of the Cotton Processing Division of the Southern Regional Research Laboratory at New Orleans. He will direct investigations involving the processing and utilization of cotton lint, including work on developing new and improved manufacturing processes, yarns, fabrics and other products composed wholly or in part of cotton.

DR. RAYMOND C. PARKER, until recently an associate in experimental surgery at the Rockefeller Institute for Medical Research, New York, has accepted a position with E. R. Squibb and Sons, at New Brunswick, N. J., where he will be in charge of the Virus Division of the Biological Laboratories.

THE Committee on Scientific Research of the American Medical Association has made a grant to Dr. Fritz Schiff, of the department of bacteriology and serology of Beth Israel Hospital, New York City, to be applied toward his work on the serological classification of Salmonella, and a grant in support of work on the physiology of the peripheral blood vessels by Dr. Roy H. Turner, of the department of medicine of Tulane University.

DR. MARGARET E. LEWIS, of the Johns Hopkins University, will join the staff of the new Crocker Radiation Laboratory of the University of California. She plans to undertake an investigation of the effect of neutrons on tissue cultures.

AT Lehigh University Dr. Lawrence Whitcomb is in charge of the summer school of geology. Dr. R. D. Butler is with the London Mines and Milling Company, Alma, Colo. Dr. D. M. Fraser is engaged in prospecting for petroleum for the Atlantic Refining Company in Cuba. Dr. B. L. Miller has continued his investigations of the geology of Lehigh County, Pennsylvania. Dr. Bradford Willard is engaged in studies of the Ordovician shales of Berks and Lehigh Counties. Drs. Fraser, Miller and Willard have recently received *per diem* appointments with the Pennsylvania Topographic and Geologic Survey.

VICTOR E. LEVINE, professor of biological chemistry and nutrition at the School of Medicine of Creighton University, is on his fifth trip to the Arctic, continuing medical and biological studies of the Eskimo under the auspices of the U. S. Public Health Service. His base this year is Kotzebue, north of the Arctic Circle.

THE eighteenth International Geological Congress will be held in London from July 31 to August 8, 1940. Titles of papers to be presented must be in the hands of the General Secretaries, Dr. W. F. P. McLintock and Professor W. B. R. King, Geological Survey and Museum, Exhibition Road, South Kensington, London, S.W. 7, not later than June 1 and the manuscripts by July 1, in a typewritten form, with illustrations, etc., ready for publication. A large number of excursions under the guidance of leading specialists both before and after the congress have been arranged. These include practically all places of geological interest in Great Britain.

AN Institute for the Consideration of the Blood and Blood-forming Organs will be held by the Medical School of the University of Wisconsin on September

4, 5 and 6. The Wisconsin Alumni Research Foundation has made available the necessary funds to finance this institute. Among those who will take part are Dr. L. J. Witts, professor of chemical medicine at the University of Oxford, and Dr. E. Meulengracht, professor of chemical medicine at Copenhagen. The subjects to be discussed include various forms of anemia and the therapy of anemia; the etiology and therapy of granulocytopenia; the formation of hemoglobin; hemorrhagic diseases; leukemia; diseases affecting lymph nodes.

THE name of the Eugenics Record Office, at Cold Spring Harbor, Long Island, N. Y., has been changed to Genetics Record Office. This office is associated with the Department of Genetics of the Carnegie Institution of Washington.

THE chairman of the Board of Agriculture of Bermuda, Sir Stanley Spruling, has outlined the results of an emergency survey recently completed by the Department of Agriculture. Cultivated and uncultivated lands of Bermuda have been surveyed as to crop potentialities and employment in the event of war. The whole plan would not go into operation immediately on the outbreak of war unless the tourist trade, the mainstay of business in the island, had declined seriously. It was stated that an agricultural survey by experts from Cornell University might be undertaken.

MANY bird-watchers in the British Isles, according to the London *Times*, have collaborated in field work under the British Trust for Ornithology, of which the fourth report has been issued. More than one hundred observers recorded day by day the exact song-periods of the misselthrush, songthrush, blackbird, chaffinch, yellowhammer and skylark. This inquiry was continued until recently, because of the abnormal weather of last winter and spring, which caused a scarcity of winter song. More than 150 heronries in 64 counties of the British Isles were visited last year by trust observers, who found that the breeding stock of herons is about at the level of ten years ago, although one Kent heronry had reached a size never before recorded since a systematic census work on this species began in Great Britain. For the little owl inquiry 73 helpers sent material from 34 counties, apart from a large number who sent notes but no material. The national bird-marking scheme was taken over by the trust last year, when more than 45,000 wild birds were marked with rings in the British Isles. Among interesting results of this work were the finding of a rook aged twelve and a blue tit aged at least eight which is still flourishing.

SIR BUCKSTON BROWNE, retired surgeon, donor and honorary curator of Down House, Kent, which was for forty years the home of Darwin, has written the following letter to the London *Times*: "Sir Charles Lyell's second edition of his 'Elements of Geology' appeared in 1841. He annotated a copy in view of another edition, and on the fly-leaf, under 'Addenda,' in his own hand, the following entry appears—'Darwin recommends a short chap. on metallic veins, giving the present state of our knowledge. He denies seeing a beginning to each crop of species. Jan. 26, 1842.' Mrs. Lyell, Sir Charles' sister-in-law, afterwards gave the book to the late Mr. Benjamin Harrison, the celebrated, self-taught, village geologist. It is now in the possession of Mr. Sidney Spokes, M.R.C.S., of Lewes, and will be presented to Darwin's old home, Down House, Do vne, Kent, now preserved as a national memorial. This precious little bit of manuscript shows that in 1842 Darwin had fully realized his 'Origin of Species.' He was, however, so patient, so conscientious, in his search for truth that 17 years were to pass before, in 1859, the immortal book appeared."

DISCUSSION

COMPOUND WORDS

IN the current issue of SCIENCE, just received, Dr. H. J. Conn presents an interesting discussion[1] of the confusion occasioned by the orthodox use (and non-use) of hyphens in the making of multiple compound words. The examples are well chosen from biological terms; but the biologists have no monopoly on such hyphenated chaos. The current issue of *Economic Geology* presents a very instructive example.

An article by E. C. Dapples[2] is entitled: "Coal Metamorphism in the Anthracite-Crested Butte Quadrangles, Colorado." To any one familiar with the region, it is quite obvious that the territory under discussion comprises two adjacent areas, designated respectively as the Anthracite Quadrangle, and the Crested Butte Quadrangle; to others, the connective implication of the hyphen, as used, suggests a butte crested with anthracite. Evidently the "others" include the headline writer for the journal in question; for, in compressing the title to a page heading, he eliminates the pseudo-adjective "anthracite-crested," and has, as a condensed title at the top of fourteen pages, the amazing and amusing contraction: "Coal Metamorphism in Butte Quadrangles." Any geologist will at once connect the term "Butte Quadrangles" with an area in Montana, in which no coal occurs.

In the closing paragraph of his discussion, Dr.

[1] H. J. Conn, SCIENCE, 89: 582–3, 1939.
[2] *Economic Geology*, 34: 4, 369–398, June–July, 1939.

Conn expresses the hope that some system may be devised "to show which elements belong most closely together and which are related to the others more indirectly." His wording here is excellent, and clearly expresses the crux of the problem. It appears that originally the hyphen was used rather freely as a connective; later practise has tended to eliminate the hyphen in compound nouns, except in connecting words of strictly coordinate import. This rule works well for simple or singly compounded words; but with multiple compounds, we need a connective factor for the units of the simple compounds and a separative factor for the compound units of the larger and more complex terms.

In the examples that Dr. Conn cites, it appears that the omission of the hyphen (according to standard practise) suggests a separation of the words in the unit-compounds, while the use of the hyphen between the unit-compound elements appears to tie together those factors that should be separated. Perhaps this seems as pedantic as the question whether the primary function of the mortar in a wall is to hold the bricks together or to hold the bricks apart (I once saw two tipsy brick-masons stage a fight to settle that problem!); but I think it contains the key to the solution of our difficulty.

If the connective implication of the hyphen is so strong as to be confusing, what might we use as a separative factor? May I suggest the disused colon? The colon has gone almost out of fashion in present-day writing; but the mathematicians still use it in their formulas to express a definite comparative relationship. Why may we not do the same in technical writing?

The suggested use of the colon as a separator and the hyphen as a connector is as simple as it is unorthodox. It includes only two rules, which are: (1) In multiple compound words, the single terms of each compound unit are to be connected by a hyphen (whether or not the hyphen would be so used if the unit term stood alone). (2) The compound units are to be separated by colons.

Using Dr. Conn's terrifying examples, they would be expressed as "safranin: orange-G: crystal-violet technic," and as "iron-alum: hematoxylin-phenol: Bismarck-brown Y schedule" (or perhaps "Bismarck: brown-Y schedule"; I am afraid that I shall have to ask Dr. Conn to interpret that one).

The sole merit of such a system is that it makes the meaning of a multiple compound term entirely clear. I have used it repeatedly in class discussions, and it has proved quite adequate, at least in blackboard work.

STERLING B. TALMAGE
NEW MEXICO SCHOOL OF MINES

THE recent discussion on compound words by Weatherby[1] and Conn[2] presented two interestingly different points of view. The former treated the question without even mentioning that admirable if ancient device, the hyphen, although the heading of his communication, "Compound Words in *Present-day* English," embodied the principle that he failed to invoke. One wonders whether the "mental epidemic" of compounding which he foretells (giving as a sample, "Costanalysis of Scholarlyperiodicalprinting") will not have been started, not by the Greeks and the Germans, but by the author of "Ulysses" and "Finnegan's Wake"? (On the first page of the latter occurs the curious portmanteau "upturnpikepointandplace" —just for example.)

Conn's entertaining picture of the endless editorial battle of the hyphen added details that had seemingly been overlooked by Weatherby. Single-word compounds (*e.g.*, blackbird) are likely to have hyphened compounds (black-bird) as their forerunners; and as Fowler[3] says, "The conversion of a hyphened word into an unhyphened single one is desirable as soon as the novelty of the combination has worn off, if there are no obstacles in the way of awkward spelling, obscurity, or the like." But often there are such obstacles. And that same indispensable mentor, ***ibidem,*** offers something like the "rules," for hyphening "double-barrelled adjectives," that Conn (and perhaps all of us) cannot find in our grammar-books:

> Mr. Lloyd George (without a hyphen) forms the Lloyd-George Government (with one); the need [for hyphens] is still greater when further complications come, but the result is then unsatisfactory—the Lloyd-George-Winston-Churchill Government. Obviously connexions of a different power are needed; a short & a long hyphen (-, –), or a single & a double one (–, =), would do (the Lloyd-George—Winston-Churchill Government, the Lloyd-George=Winston-Churchill G.); but this is an innovation that would hardly find acceptance; & is better than — or = (the Lloyd-George & Winston-Churchill G.); better than either is some evasion, the George-Churchill G., or the G. of Messrs. Lloyd George & Churchill.

Their unfamiliarity aside, there might still be some (rather remote) possibility of confusing the "long" hyphen with the dash, the "double" hyphen with the "equals" sign. (These objections could be disposed of —except perhaps among the typographical profession —by setting the new symbol slightly above or slightly below the center of the line of type.) Is it not more likely that the "real" reason why such devices would not be generally acceptable is merely that it will always

[1] C. A. Weatherby, SCIENCE, 89: 413, 1939.
[2] H. J. Conn, SCIENCE, 89: 582, 1939.
[3] H. W. Fowler, "A Dictionary of Modern English Usage," Clarendon Press, p. 244.

be easier not to seek precision—not to "bother," even about "short" and "single" hyphens? And yet, as any reader of these musings who knows the work of Korzybski[4] will already have reminded himself, "Hyphens allow us in principle to make compound words structurally similar to the non-elementalistic world we happen to live in."

R. H. BAUGH

COLLEGE OF PHYSICIANS,
PHILADELPHIA

WEATHERBY in a recent note[1] says that "The English language is rapidly acquiring a facility in forming compound words comparable to that possessed by ancient Greek and contemporary German." It should not be difficult to convince writers who wish to be understood that they might follow better models than classical Greek, which has now become a "dead" language, or modern German, which has never been known especially favorably either for clarity or ease of reading. Moreover, I question whether the language really *is* changing. ***Unit modifiers*** always have been used, especially by scientists who were poorer writers than researchers. What is now happening is that we are losing our critical faculties in writing English; the result is that technical writing is full of errors that any one well grounded in the proper use of English would notice immediately. Weatherby cites a few examples of "present-day" English to prove that the language is changing; he is merely proving that it is possible to write poorly and "get away" with it. For instance, he says that thirty years ago no one would have put forth such a title as 'Cost Analysis of Scholarly Periodical Printing." It is still true that no one would write such a title if he hoped to be understood perfectly. Does that title mean, as Weatherby suggests, "An Analysis of the Cost of Printing Scholarly Periodicals?" Perhaps so, but rather it seems to mean "An Analysis of the Cost of Printing Periodicals Scholarly"—a cost (one feels sure after reading much of the current scientific balderdash) that would be much more than that of printing scholarly periodicals. Maybe Mr. Weatherby is right, and in the somedaydistant-future we shall all be compoundedlyunitmodifying, but if this mentalepidemicurge he speaks of ever truly possesses us, Heaven help our desiringtounderstandus-readers.

ORAN RABER

SOUTHERN FOREST EXPERIMENT STATION,
NEW ORLEANS

[4] A. Korzybski, "Science and Sanity," Science Press Printing Company, pp. 31, 243; "General Semantics," Arrow Editions, p. 34.

[1] SCIENCE, May 5, 1939, p. 413.

GRANTED that at best hyphenation is a bothersome subject, your correspondent, H. J. Conn, editor of *Stain Technology,* does not seem to be aware of two common rules which simplify the matter somewhat. One is the rule followed by the Chicago University Press and many other people: "Hyphenate adjectival phrases formed of two or more words when preceding the nouns modified, where ambiguity might result." Mr. Conn's phrase "safranin-orange G-crystal violet technic" would become "safranin orange-G crystal-violet technic." The other rule from the same source: "Where one of the components of a compound adjective contains more than one word, an en dash should be used in place of a hyphen." This would make "the Great Northern–Northern Pacific railway system" a manageable term and could be applied also to the "safranin" phrase if preferred.

Mr. Conn has further complicated his problem by not having discovered that the current unabridged Webster (1935) omits the hyphen after non- as a prefix and has made one word of "sporeformer." "Nonsporeformer" is a good example of the very trend Mr. Conn has been desiring.

MARJORIE FULLER
JANE MCMASTERS

THE TECHNOLOGY REVIEW

VALUE OF CHARACTERS OF THE UNDEVELOPED SHOOT IN IDENTIFYING PLANTS

IN many cases foresters and range workers find they must identify woody plants such as forest trees or shrubs in winter condition. In range surveys or quadrat studies it often becomes necessary to ascertain the name of a grass in the early season before the appearance of the inflorescence. Various keys and description are available for this purpose, but very often a positive specific identification can not be made, due to the very nature of the material. Where the plant can be studied again later in the season, this difficulty is not serious. Often this later check can not be carried out. It is the purpose of this article to call attention to the characters of the undeveloped shoot as an aid to the immediate identification of such material.

The leaves and flowers inside the winter buds of woody plants can be so studied. In grasses information gained by dissecting out the small inflorescence which lies in the sheath tube about at ground level may allow for a more definite determination.

The technique of this dissection is not intricate. In woody plants the bud scales can be removed and the shoot exposed for study. In order to have both hands

free the writer uses a dissecting microscope equipped with a foot-focussing device. This machine was described in SCIENCE[1] and is now for sale by the Spencer Lens Company of Buffalo, N. Y. However, even with a good hand lens leaf characters, such as vernation, general shape, type of base and apex, kind of margin and venation, can usually be made out. In addition, the buds may inclose flowers far enough along so that floral characters such as number and type of sepals, petals, stamens and pistils can be ascertained. In many cases unknown species can actually be run through the keys of manuals based on floral and leaf characters.

In grasses the sheath tube of a large vigorous culm can be split longitudinally and the incipient inflorescence exposed. The type of inflorescence can be determined, in most cases the florets of a spikelet can be counted and many of their characters can be made out.

In many instances these undeveloped, concealed characters in woody plants and grasses are definite enough to actually allow for identifying the plant in ordinary manuals. However, in most cases their greatest value will probably be in helping decide between several possibilities or in allowing for a positive check on what otherwise might be an uncertain identification.

H. D. HARRINGTON

COLORADO STATE COLLEGE

CYSTINE AND METHIONINE REQUIREMENTS FOR GROWTH AND LACTATION

RECENT studies have shown that the sulfur-containing amino acids promote lactation in rats when fed with rations in which the protein is derived from casein or alfalfa leaf meal. Since these proteins are deficient for growth in their combined contents of cystine and methionine, it does not necessarily follow that cystine and methionine should be regarded as lactation stimulants merely because they promote lactation when fed with these proteins.

We have recently determined the growth and lactation responses in rats fed alfalfa leaf meal proteins supplemented with various levels of cystine. We have also determined the growth and lactation responses to cystine and methionine when fed with peanut meal protein. Cystine does not significantly improve the growth- and lactation-promoting properties of peanut meal protein. Methionine improves both properties. Our results indicate that the combined requirements for cystine and methionine and the conditions governing the interchangeability of cystine and methionine are of essentially similar orders for growth and lactation.

J. R. HAAG

L. D. WRIGHT

OREGON STATE AGRICULTURAL COLLEGE

SCIENTIFIC BOOKS

THE THEORY OF NUMBERS

An Introduction to the Theory of Numbers. By G. H. HARDY and E. M. WRIGHT. The Oxford University Press. Octavo: xvi + 403 pp. $8.00.

MATHEMATICS undergoes continuous revitalization through two main currents of thought: the one flowing from the inexhaustible supply of simple conundrums concerning the positive integers; the other flowing out of new conceptual ideas necessary for the comprehension of natural laws. For example, to quote Cajori,[1] "in the study of the right triangle there arose questions of puzzling subtlety. Thus, given a number equal to the side of an isosceles right triangle, to find the number the hypotenuse is equal to. . . . The problem may have been attacked again and again. . . . In some such manner arose the theory of irrational quantities"—as a byproduct of the attempt to solve an arithmetic problem without rational solution. Similarly the imposing edifice of Euclidean geometry grew out of the physical concepts based on exact spatial measurement.

[1] H. D. Harrington and R. W. Poulter, SCIENCE, 79: 368–369, April 20, 1934.

[1] "History of Mathematics," second edition, pp. 56–57.

In the fascinating volume by G. H. Hardy and E. M. Wright under review here we find a remarkably happy and varied selection of important arithmetic problems treated with consummate clarity and distinction. The book will appeal to the many non-professional devotees of number theory and to professional mathematicians generally. As a basis for an attractive and profitable first course on the theory of numbers one could not find a better text. The title is the same as that of a well-known volume by our great American number-theorist, L. E. Dickson. But there is little overlapping, and no real confusion will be caused.

It will enhance the value of the work to mathematicians that one of the two distinguished authors (Hardy) has not only contributed greatly to the advancement of the subject on the side of the so-called "analytic theory of numbers" but also has long been one of the most inspiring mathematical figures in the world. We recall too his close association with the short-lived genius, Ramanujan of India, with the lamented Landau of Göttingen and with his remarkably gifted colleague Littlewood at Cambridge, all of whom have done so much for number theory.

Although the pages of the book treat a large variety

of topics, nevertheless it is truly stated by the authors in the preface that "in the first eighteen chapters we assume nothing that is not commonly taught in schools, and any intelligent university student should find them comparatively easy reading. The last six are more difficult, and in them we presuppose a little more, but nothing beyond the content of the simpler university courses." The authors have discussed the distribution of primes, Farey series, the geometry of numbers of Minkowski, irrational numbers, the theory of congruences, Fermat's theorem and related topics, decimal representation of numbers, continued fractions, approximation of irrationals by rationals, algebraic integers, Diophantine equations, the familiar arithmetical functions, partitions, representation of numbers by two or four squares, Kronecker's theorem in one or more dimensions. In every case the discussion given is on an elementary level so far as technical knowledge is presupposed, but on a genuinely professional level as far as insight and thoroughness are concerned.

A valuable feature of the book is the bibliographic material in small print at the end of each chapter, which furnishes an excellent orientation in the relevant literature.

It is much to be hoped that other mathematical works having the appeal of the book by Hardy and Wright will soon be written; and that a much wider public than at present will come to realize how through such works the highest artistic and intellectual enjoyment may be obtained, only to be compared with that to be derived from literature, art and music.

GEORGE D. BIRKHOFF

THE PRINCIPLES OF INSECT PHYSIOLOGY

The Principles of Insect Physiology. By V. B. WIGGLESWORTH, London School of Hygiene and Tropical Medicine. 434 pp., 316 illustrations. London, Methuen and Company, Ltd. 1939. 30 shillings net. New York, E. P. Dutton and Company.

WITH the appearance of "The Principles of Insect Physiology" the subject of entomology acquires a new dignity and the right to claim a place in the higher ranks of biological science. Too long we have been fed with mere "wonders" and "marvels" of insect life. The numerous citations given in the present work show, however, that during the last few decades many serious workers, unproclaimed to the general public, have been diligently searching for the underlying causes and principles of the much-heralded wonders and marvels, with the result that we now have a full-fledged text on insect physiology. The author of the book, himself a leading investigator in this field, has brought together in admirable form the gist of what may now be regarded as a sound basis for the scientific study of insect functions and behavior. The book should be welcomed particularly by all teachers and students of entomology, since it is well recognized that further advance in economic entomology must depend largely on an understanding of insect physiology.

Unfortunately it is not possible for most entomologists to be trained physiologists, but the style of "The Principles of Insect Physiology" is such that the text can be read and understood by any entomologist whether or not he has been schooled in physiological technique and terminology. The treatment is informative rather than discussional, and the book is not a manual of laboratory practice. The subject-matter is divided into 15 chapters under the following headings: Development in the Egg; Integument; Growth, Muscular System and Locomotion; Nervous System; Vision; Mechanical and Chemical Senses; Behaviour; Respiration; Circulatory System and Associated Tissues; Digestion and Nutrition; Excretion; Metabolism; Water and Temperature; Reproductive System. Each chapter is accompanied by a list of references, cited by numbers in the text, varying from 48 to 265 for single chapters, a total of over 2,000 with a few repetitions. The 316 illustrations are entirely line drawings, and thus give a pleasing uniformity to the general appearance of the pages. Anatomy and histology are given briefly wherever necessary for the elucidation of the subject-matter, and in many cases the up-to-date information on these subjects contributes much to the value of the book.

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SOCIETIES AND MEETINGS

THE ROYAL SOCIETY OF CANADA

THE annual meeting of the Royal Society of Canada was held at the invitation of the University of Montreal in the new Botanical Building from May 22 to 24. A large attendance of fellows from all parts of Canada had an opportunity of seeing this splendid new development of a Botanical Garden in Montreal with its research laboratories, greenhouses and large park still in the process of completion as a works project financed by civic and government authorities and under the direction of Frère Marie-Victorin, of the University of Montreal.

The presidential address was delivered by Dr. Victor Morin, who spoke on "La Chanson Française a travers les siecles," with interpretations of songs by the *Quatuor des Alouettes.* This address was preceded by the introduction of new fellows and by the presentation of medals awarded by the society. The Flavelle Medal

was awarded posthumously to the late Professor J. Playfair McMurrich in recognition of his distinguished work in anatomy. Dr. Wilfred Bovey received the Lorne Pierce medal, and the Tyrrell medal was presented to Dr. E. Z. Massicotte. A unique social feature of the meeting was the operetta-dinner held in the ballroom of the Mount Royal Hotel, at which the fellows and their wives were the guests of the City of Montreal. This fanciful dinner-play was written by the president of the society, Dr. Morin, as a reconstitution of the feasts given by the "seigneurs" of olden times. Parodical rhymes on gastronomical subjects adapted to the music of well-known operas of the French repertory were sung by artists in cook's and maid's costumes, as the several dishes of the dinner were served. At the concluding general meeting, Dr. H. M. Tory was elected the new president of the society.

Section III (Chemical, Mathematical and Physical Sciences) was held under the presidency of Professor S. Beatty, who delivered the presidential address on "Generalization as a Principle of Mathematics." Three new members were elected to this section, Professor H. N. Brocklesby, Professor M. F. Crawford and Professor G. Herzberg. In all, 120 papers were presented and the section divided into the three subdivisions to facilitate the giving of the papers during the time of the meeting. Space permits reference to only a few papers read. Professor E. F. Burton spoke on a number of papers contributed by his co-workers, among which special mention should be made of the recent results obtained by Johns, Wilhelm and Grayson Smith on the flow and viscosity of liquid helium, in which it was proved by using glass capillaries ranging from 0.025 cm to 010036 cm in diameter and with lengths varying from 2 cm to 26 cm that normal laminar flow was obtained for He I with a viscosity of the order of 10^{-5} c.g.s. units, while for He II, the flow could be expressed as the sum of a laminar flow plus an additional pressure-independent flow. The laminar portion obeyed Poiseuille's law and gave a viscosity of the order of 10^{-5} c.g.s. units. The new electron microscope constructed by A. Prebus and J. Hillier and photographs obtained with it indicating high resolving power were described by Dr. Burton. Among the papers presented by Professor J. A. Gray, one in collaboration with J. S. Marshall and A. G. Wood contained results on the scattering of β rays using metallic foils, which were in contradictions to those obtained by other observers using expansion chamber methods. Dr. D. C. Rose described an electromagnetic pick-up device used with a cathode ray oscillograph for investigating vibrations in aeroplanes during flight. A new method of observing the Raman effect in small amounts of liquid with short exposure times was presented by Professor M. F. Crawford and H. L. Walsh. A description of the methods now being used to determine the upper earth structure from data obtained by registering the seismic waves from rock bursts occurring in mines was given by Dr. E. A. Hodgson. Other papers on field results of geophysical investigations were given by Dr. A. A. Brant, Professor L. Gilchrist and Professor D. A. Keys. The results of an analysis of meteorological data by A. Thomson showed that the average winter temperature was 4° F. warmer in Manitoba and Saskatchewan for the period of 1919–38 than for the period 1884–1903, which was explained by the increase in the temperature of the air masses moving in from the Arctic circle.

Among the fifteen papers presented by Professor O. Maass and his associates, particular interest was taken in those dealing with the measurements of viscosity, opalescence, specific heat, density and solubility relations of various liquids and vapors in the critical temperature region. The influence of intense mechanical stirring on the temperature at which the disappearance of the meniscus takes place shows that a wide range of overall density gives identical critical temperatures. Professor E. W. Steacie presented eight papers dealing with various aspects of photosensitized decomposition. Professor R. H. Clark and his collaborators contributed fourteen papers, among which special mention may be made of the results obtained on activators of zymase. The plant hormones activate live yeast but have little accelerating effect on zymin. Another paper of interest was on the mechanism of the flotation of galena in the presence of xanthate which is applied in the mining industry in Canada. Professor H. Hibbert spoke on the results obtained in his laboratory carried out with various collaborators in lignin and other wood products.

In the mathematical and astronomical section, M. S. McPhail and Professor R. J. Jeffery spoke on "Stieltjes Integrals," with applications to fractional integrals. The profiles of hydrogen line in the spectrum of H. D. 190073 by C. S. Beals and an investigation into the hydrogen line contours in the spectra of solar type stars by K. O. Wright were given by Dr. W. E. Harper. Dr. A. V. Douglas, D. C. West and D. E. Guignard described an investigation on the profiles of hydrogen lines in two class B stars.

Professor J. A. Gray was elected president of the section and Professor J. K. Robertson secretary.

In Section IV (Geological Sciences) the presidential address by Dr. M. E. Wilson outlined the development of ideas about the Canadian Precambrian and discussed certain Precambrian problems. Eighteen papers were presented. Two papers dealt with Sudbury, one by Dr. H. C. Cooke, in which some new ideas about the general geology of the district were given, and the other by Dr. A. B. Yates, concerned with the ore deposition. Dr. H. C. Gunning and J. W. Ambrose outlined the results of five years detailed investigation of the so-called Timiskaming-Keewatin contact in Rouyn-

Harricanaw Area, Quebec. The whole succession of volcanic and sedimentary rocks is apparently conformable, and the investigations show the need for complete revision of our conceptions of Archean stratigraphy and structure in this part of the Canadian shield.

The paleontological papers included descriptions of a Helderber fauna from the eastern townships of Quebec by Dr. T. H. Clark, some species of Neo-Triassic ammonites by Dr. L. H. McLearn. Dr. J. T. Wilson presented an interesting paper on the eskers northeast of Great Slave Lake, N.W.T. The information was gained chiefly from the study of aerial photographs.

Dr. H. W. Fairbairn presented a paper on the fracture hypothesis of quartz orientation in tectonites. Dr. M. B. Baker discussed the floor of the Paleozoic rocks in Canada.

The presidential address of Section V (Biological Sciences) was delivered by Dr. J. M. Swaine, of Ottawa, on "Scientific Research as the Key to Progress in Agriculture."

The program comprised seventy-two papers, of which nineteen came before the medical subsection and twenty-nine were botanical.

Dr. N. H. Grace reported upon the relative physiological activity of the members of a series of naphthyl acids when applied to plant cuttings, showing that those with an even number of carbon atoms in the side chain are the more active. Drs. E. Gordon Young and R. W. Begg found certain small proportions of copper, calcium, magnesium and iron to be required in bacterial culture media. Factors affecting stomatal movement in the dark were described by J. H. Whyte. That increased permeability of the host accompanies increased susceptibility to parasites and diseases in plants was shown by F. S. Thatcher. The importance of boron for normal cell division, enlargement and maturation in plants was described by J. G. Coulson and R. O. Lachance, while studies related to hardiness of plants were reported by Messrs. J. Levitt and D. Siminovitch. R. B. Thomson discussed the structure of the pollen cone of Austrotaxus and its phylogenetic significance, showing it to be a highly specialized derivative of the usual conifer type, and C. N. Haldenby described the distribution and origin of horizontal resin canals in Coniferae. A series of papers by Frère Marie-Victorin was devoted to various taxonomic and distributional studies of the plants of Quebec and of Cuba, interesting contributions to the problem of relic floras being made, particularly in papers by Mm. Rousseau and Gauthier.

In the field of genetics, a definite relationship between sterility and chromosome segregation with translocations was demonstrated in wheat crosses by W. P. Thompson and the actual causes of failure of seed-setting in certain intergeneric cereal crosses were described in another paper by the same investigator. F. H. Peto gave an account of the production of fertile amphibolypoid plants from sterile hybrids of Triticum species and *A. glaucum* by temperature and colchicine treatments, with cytological studies of the processes involved. Certain chromosome mutations in oats were shown by H. G. F. Sander to involve loss of all or parts of one chromosome and studies on the chromosomes of Trillium by G. B. Wilson and H. B. Newcombe gave data which can not readily be fitted to any existing theory of crossing over but suggest a new partial hypothesis.

Features of the morphology of the circulatory system of Amia, particularly in relation to an air-breathing mechanism, were described by V. C. Wynne-Edwards, and the presence of a vessel of portal nature connecting the hypothalamus in the frog was reported by E. Horne Craigie. The latter also demonstrated wide and important differences in the vascular richness of hypothalamic centers in the rat. Various studies on the white whale were reported by V. D. Vladykov, who also discussed sexual dimorphism in the trout populations. An account of differential growth rates and of regeneration in the hind limb of the frog was offered by A. Emerson Warren. A study of temperature relations of the numerous species of midges (Chironomidae) occurring in a lake was described by R. B. Miller.

B. P. Babkin and associates showed that ergosterol and parathyroid hormone effect gastric secretion in the dog chiefly by depressing its nervous phase. Early cessation of growth in rats on a rich fat diet was found by R. G. Sinclair and traced to the masking or suppression of synthesis of essential fatty acids. The effect of guaiacols on the respiratory passages was described by E. M. Boyd. Authentic notochordal tissue in a dermoid cyst of the ovary was reported by J. L. Riopelle. The structure and development of certain renal tumors led P. Masson to believe that the metanephros is not mesodermal but is derived from the neural crest; while his associate, P. Simard, found a constant neuro-insular complex in the mammalian apparatus. Drs. A. Scott and A. M. Fisher gave an account of the effects of certain chemicals in activating insulin and showed by moving picture film that each insulin crystal has two parallel square surfaces relatively close together, connected by four oblique quadrilateral surfaces. James Craigie showed that the Guarinieri inclusion bodies are probably not intracellular colonies of a virus. The chemotactic attraction of staphylococci for leucocytes from mouse spleen was found by J. W. Stevenson and G. B. Reed to vary inversely with their pathogenicity, while Alma Howard reported an inverse relationship between chiasma frequency in chromosomes and susceptibility to mammary gland carcinoma in mice.

SPECIAL ARTICLES

COPPER AND VITAMIN C EFFECTS UPON THE EXCISED FROG HEART[1]

IN a preliminary report, Urban and Peugnet[2] showed that vitamin C exerts a powerful beat-strengthening action upon the perfused frog heart. Since that time, Peugnet and Urban[3] have shown that: (1) Vitamin C also accelerates the beat frequency of the abnormally slow pacemaker, with little or no effect upon the normal rate—in which it differs from adrenalin; (2) vitamin C frequently increases the diastolic "tonus," though not as yet reproducibly; (3) inotropic effects are obtainable in concentrations as low as .05 mg per cent.; (4) vitamin C action is independent of and additive with that of perfusate glucose; (5) vitamin C action is not due to atropine-like vagus paralysis, nor to removal of inhibitory action of perfusate potassium, nor to calcium contamination of the vitamin C; (6) oxidized (iodine) vitamin C is inactive.

In the present communication, the author wishes to present experiments proving that the action of vitamin C on the frog heart requires the presence of copper.

The method is that of Straub, described in detail by McLean and Hastings.[4] Ringer (glucose-free) solutions are made with Kahlbaum (analytical) chemicals and Pyrex-distilled water, and contain $NaHCO_3$ (0.2 per cent.), being continuously bubbled, both in reservoir vessels and in cannula, with 95 per cent. O_2–5 per cent. CO_2. Vitamin C is the synthetic crystalline material.[5]

The experimental evidence for the necessity of copper in the action of vitamin C is briefly as follows:

(1) The inotropic action is always present (about 40 experiments) with ordinary "reagent quality" chemicals and metal-distilled water.

(2) The effect is absent (14 out of 16 experiments) with Kahlbaum chemicals and Pyrex-distilled water.

(3) The heart which fails to respond to vitamin C alone does respond when copper is added to the perfusate (0.1–4.0 micro-mols per liter copper ion, as chloride).

(4) In the same heart, copper alone is ineffective until the addition of vitamin C.

(5) Vitamin C alone can not maintain the inotropic increase, but requires the continued presence of copper in the perfusate.

(6) The heart which does respond to vitamin C alone gives a greater response with copper in addition.

It is particularly to be noted that the response to the addition of copper (vitamin C already present) occurs only after a latent period, or "induction" period, whereas the response to vitamin C addition (copper already present) begins immediately. (The technique in the two cases is as nearly identical as possible; the copper and the vitamin C are freshly mixed with Ringer a few seconds before each application.) This induction period is never seen with vitamin C, and appears to be a constant phenomenon with copper. The duration of the latency varies roughly inversely with the copper concentration (see Table I).

TABLE I

Frog Date	Copper Ion. micro-mol./L	Induction per. (sec.)
5–25–39	0.4	240.
6–4	2.0	90.
5–10	2.5	110.
5–24, A	4.0	30.
5–24, B	4.0	35.

As to the nature of the induction period, it appears certain that this delay is not due to any *in vitro* reaction or "activation" time, since the time during which the two are in contact *in vitro* is the same whether or not the tissue has been previously exposed to the copper alone; and, as already mentioned, the previous "conditioning" of the tissue with copper abolishes the delay. Apparently, then, the copper is necessary in some part of the tissue system which utilizes vitamin C. Further experiments on this question will be presented at a later date.

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[1] Aided by grant of the Ella Sachs Plotz Foundation.

[2] F. Urban and H. B. Peugnet, *Am. Jour. Physiol.*, 123: 207, 1938.

[3] Exhibited with F. Urban at the American Medical Association Convention, May, 1939.

[4] F. C. McLean and A. B. Hastings, *Jour. Biol. Chem.*, 107: 337, 1934.

[5] Donated by Merck and Company.

PROLONGED THERAPEUTIC EFFECT OF SUBCUTANEOUSLY IMPLANTED CRYSTALS OF OVARIAN HORMONE IN WOMEN

THE investigation reported here was undertaken to determine whether it is possible to prolong the physiologic effects of a given dose of estrogenic hormone in humans by implanting crystals of the hormone, subcutaneously. It appears from the results of various investigations that the high dosage of estrogens required to relieve symptoms caused by ovarian failure and to maintain the endometrial and vaginal mucosa in a normal physiologic state is in a great part attributable to the rapid absorption and excretion of the hormone. To achieve a satisfactory therapeutic effect at present it is necessary to administer intramuscular

injections of a solution of the hormone in oil at frequent intervals for periods of many weeks. Aside from the inconvenience caused the patient by the necessity for frequent injections, there is the additional factor of expense which places this form of therapy beyond the means of the majority of patients. In the interests of economy and the patient's comfort, it would appear to be highly advantageous to have an estrogenic preparation which would be absorbed slowly so that the patient may derive a fuller measure of benefit from a given amount of the hormone and obviate the necessity for frequent injections. An attempt was made to achieve this objective by the implantation of crystalline a-estradiol benzoate, subcutaneously.

TECHNIQUE

Crystals of the hormone were placed in small glass tubes measuring 3 mm in diameter and 1½ cm in length and sterilized by autoclaving. The amounts varied from 4 to 7 mgm. The implantation was performed in the gluteal region. The skin was prepared with tincture of iodine and alcohol. An area of skin measuring approximately 1½ inches in diameter was infiltrated with 2 per cent. novocaine. An incision measuring 1 inch in length was made and the capillary oozing controlled with a dry packing. The estradiol benzoate crystals were then implanted into the wound and the skin edges approximated with 2 silk sutures. The sutures were removed 5 days later.

A total of 10 menopause cases were so treated, including patients with surgical as well as natural menopause. All the patients had typical menopause symptoms and morphologic evidence of estrogen deficiency. The vaginal smear was used as an indicator of estrogen deficiency and estrogenic effect. Vaginal smears were taken twice weekly after the implantation.

RESULTS

The majority of the patients reported improvement in their symptoms as early as 6 days after the implantation. Complete relief of symptoms usually occurred within 2 weeks and has persisted to date (periods varying from 60 to 98 days after the implantation). Objective evidence of the biologic effect of the implanted crystals was noted in the vaginal smear changes as early as 4 days after the implantation. The "atrophy" cells and leucocytes began to diminish in number, being replaced by large squamous epithelial cells. At the end of 7 to 10 days, the smears consisted entirely of large squamous epithelial cells exhibiting the characteristics of the smear of the normally menstruating woman. This evidence of continued activity has persisted to date (periods varying from 60 to 98 days).

Inasmuch as 1 mgm of a-estradiol benzoate is equivalent to 6,000 R.U., these patients were given doses varying from 24,000 to 42,000 R.U. of estrogenic hormone. This amount, when administered in solution in oil, in a single dose, intramuscularly, will, in the average menopause case with a well-developed menopause syndrome, produce only an incomplete effect both on the symptoms and vaginal smears. Unless repeated injections are administered the symptoms recur in their original intensity and the smears show evidence of regression to the pre-treatment state within 7 to 14 days after the injection.

It appears that crystalline a-estradiol benzoate, when implanted subcutaneously in women who have clinical and morphologic evidence of ovarian deficiency, exerts an effect which is strikingly more pronounced and more prolonged than is obtained with comparable doses of the hormone administered intramuscularly in solution in oil. This prolonged effect is attributed to the slow rate of absorption and excretion of the hormone.

Judging from the prolonged effect exerted by the small amounts of hormone used here, it is logical to expect that by implanting larger amounts of hormone (25 to 50 mgm) it will be possible to keep a patient symptom-free for periods of many months. This method of administering estrogens, it seems to us, has great therapeutic potentialities. In addition to being applicable to various types of cases of ovarian failure (natural menopause, functional amenorrhea, x-ray and radium castrates, etc.), it is suggested that it can be employed prophylactically at the time of surgical removal of the ovaries to prevent the development of the artificial menopause.

Further studies are being carried on in a larger series of cases to determine the duration of the effect in relationship to different amounts of the hormone implanted in order to ascertain the optimal amount of hormone for various clinical conditions.[1]

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THE INFLUENCE OF 3-INDOLE-ACETIC ACID ON POLLEN GERMINATION

THE presence of auxin in various kinds of pollen has been shown by several investigators.[1] Although several hundred papers have been published on growth substances, apparently no work has been done on the influence of auxin on the germination and growth of pollen tubes. The present writer is studying the effects

[1] We are indebted to Dr. Erwin Schwenk of the Schering Corporation, Bloomfield, N. J., for the crystalline a-estradiol benzoate used in this investigation.

[1] F. W. Went and K. V. Thimann, "Phytohormones." New York, 1937.

of heteroauxin on the rate of germination, the percentage of germination and the rate of elongation of the pollen tubes of several different species. The results obtained from five species seem worthy of a preliminary report.

TABLE I

MEASUREMENTS ON POLLEN GERMINATION AND TUBE GROWTH WITH AND WITHOUT 3-INDOLE-ACETIC ACID

Pollen	Rate of germination in minutes		No grains counted		Percentage germination		Average four-hour tube length in microns*	
	Test	Control	Test	Control	Test	Control	Test	Control
T. occidentalis	2–3	4–6	1453	1274	84%	61 %	920	590
T. canaliculata	2–3	4–6	1240	1042	80 "	62.5 "	350	208
Polygonatum	15–18	25–28	1272	1240	58 "	37 "	450	220
Lathyrus odoratus .	25–30	90–100	1475	1535	76 "	40 "	163	86
Pinus Austriaca ...	6 hrs.	No ger.	1200	1500	51 "	00 "	75	00

* The tube measurements on *Pinus* were made in twelve hours.

Pollen grains of *Tradescantia canaliculata, T. occidentalis, Polygonatum commutatum, Lathyrus odoratus* and *Pinus Austriaca* Höss were cultured in solutions of sucrose (C.P.) in twice-distilled water. A 3 per cent. sugar solution was used for *Polygonatum* and the two species of *Tradescantia*; a 10 per cent. solution was used for *Lathyrus* and *Pinus*. These concentrations were chosen because preliminary trials had shown that they caused no plasmolysis or plasmoptysis. For each experiment two solutions were prepared with exactly the same concentration of sucrose, and to one of them enough 3-indole-acetic acid was added to be of a concentration of one part per million parts solution. The other solution was used as a control. The solutions were made up each time a group of cultures were started in order to prevent bacteria and mold from bringing about changes. The pH of the solutions was 6.4 ± 0.1 as determined by the calomel electrode potentiometer. Brink's[2] hanging drop technique was employed. Although no attempt to control the temperature was made, it varied only within the range of 25°–27° C. A large number of slides were carried through for each species in both the sugar series and the sugar-heteroauxin series. Representative fields were counted from each slide by means of the compound microscope (100X). To determine the rate of germination, the elapsed time between inoculation and the first protuberance of the intine was noted on each slide. Extensive four-hour counts were made on all species except *Pinus* (in which case twelve-hour cultures were counted) to determine the percentage of germination. Measurements of the pollen tubes were made also on these four- and twelve-hour cultures using an ocular micrometer.

These data indicate that 3-indole-acetic acid in concentrations of 1:1,000,000 produces the following effects: (1) germination is stimulated in such a way that the pollen tube appears in considerably less time than in the control, (2) the rate of elongation of the tube is increased, (3) a much higher percentage of germination is achieved, (4) greater tube lengths are found at the end of four hours, and (5) the pollen of *Pinus Austriaca* is stimulated to germinate, whereas no germination occurred in the control.

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[2] R. A. Brink, *Am. Jour. Bot.*, 12: 149–162, 1925.

THE VITAMIN C CONTENT OF SPRING GREENS

IN connection with a course in local flora, determinations were made of the ascorbic acid (vitamin C) content of certain wild plants which have been reported as being used for spring "greens" in southern Ohio. Young leaves, collected during the spring as soon as good growth had started, were analyzed in duplicate by the 2,6 dichlorophenolindophenol indicator method as described by Bessey.[1] The results are reported as milligrams of ascorbic acid per gram of fresh weight.

TABLE 1

ASCORBIC ACID CONTENT OF CERTAIN WILD PLANTS USED AS SPRING GREENS

Common name	Botanical name	Mg ascorbic acid per gram of fresh weight
Burdock	*Arctium minus*	0.696
Chickweed	*Stellaria media*	0.377
Curly dock	*Rumex crispus*	1.349
Dandelion	*Taraxacum officinale*	1.546
Milkweed	*Asclepias syriaca*	6.556
Pokeweed	*Phytolacca americana*	2.735
*Shepherd's purse	*Bursa bursa-pastoris*	1.296
Skunk cabbage	*Spathyema foetida*	3.150
*Slender nettle	*Urtica gracilis*	1.007
Smaller leaved milkweed	*Asclepias incarnata*	2.537
Sorrel	*Oxalis stricta*	1.765
Sow thistle	*Sonchus oleraceaus*	0.633
*Water cress	*Sisymbrium nasturtium-aquaticum*	1.875
*Wild carrot	*Daucus carota*	0.748
Wild lettuce	*Lactuca canadensis*	0.636

[1] Otto A. Bessey, *Jour. Am. Med. Asn.*, 111: 1290–98, 1938.

Plants which are starred in Table 1 gave extracts colored by anthocyanins. These were removed by treating with a small quantity of Lloyd's reagent (hydrated aluminum silicate) and centrifuging. This also removes a little of the ascorbic acid but was the most satisfactory reagent for the decolorization that could be found out of a great many that were tested. It is also realized that certain other substances besides ascorbic acid can reduce the dye and that in cooking, particularly when the liquid is discarded, there may be large losses of vitamin C. The values as determined for the fresh samples are given in Table 1.

For comparison, the average of several samples of fresh spinach by the same method was 0.812 milligrams of ascorbic acid per gram of fresh weight.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A THERMAL METHOD FOR THE SEPARATION OF GASES AND ISOTOPES

Two methods are available for the separation of isotopes in quantity; one is the chemical, the other the physical. The chemical method, which will not be discussed in this paper, has been developed to a high degree of perfection by Professor Urey, of Columbia University. The physical method depends for its operation on the difference in the thermal behavior of the isotopes. As early as 1917 Chapman and Dootson[1] observed that when a gas consisting of two isotopes is placed in a tube heated at one end a slight concentration of the light component is induced in the heated portion of the tube by thermal diffusion. The effect in itself, however, is too small to serve as an efficient device for separating gases or isotopes. Within the last year processes have been developed which put the physical method on a practical basis. Clusius and Dickel[2] observed that, in an apparatus consisting of a cooled vertical tube with a heated wire down the center, an appreciable concentration of the heavy component of the gas is obtained at the bottom, while the light component rises to the top. The details given of the apparatus are so meager that an accurate description is impossible; it is stated, however, that the tubes vary in height from one to thirty meters and that the temperatures of the central wire range from 300 to 600° C. With the thirty-meter tube several liters of HCl^{37}, 99.4 per cent. pure, have been separated. These investigators describe the mechanism of operation as one arising from the combined action of thermal diffusion (the Chapman effect) which concentrates the light component at the heated wire, and to an overall convection current action which causes the gas to move upward along the heated wire and down along the cold wall. In this process the light gas is transported to the top of the tube and the heavy to the bottom.

Another modification of the thermal method has been developed in this laboratory.[3] The mechanism of separation depends on the combined action of the Chapman effect and an internal diffusion which results from the fact that molecules of different mass have different velocities when in thermal equilibrium. The basic principles involved in internal diffusion have been described in detail by Mulliken and Harkins.[4] The most effective design of apparatus so far constructed here consists of two vertical concentric glass tubes, the outer one water-cooled, while the inner one is heated electrically. In a device of this type the heat is transferred from the hot wall to the cold by a series of swirls in the intervening gas and not by an overall convection current up the hot wall and down the cold. Direct transference of heat by conduction occurs only in a thin layer adjacent to the walls. It is a well-known fact that if two molecules, one light, the other heavy, impinge on a heated plate they receive the same amount of energy, except for a slight difference due to their accommodation coefficients. In the case of isotopes the accommodation coefficients are obviously the same. In consequence, the lighter molecules, on coming in contact with the heated inner tube, rebound with the greater average velocity and hence go ahead to enrich the front rank of the expanding gas. The reverse process occurs at the cold wall. This effect is still further enhanced by thermal diffusion, which tends to concentrate the light gas at the hot surface. As a consequence of this enrichment more light than heavy molecules are trapped by the overlying gas swirl, the net result being that the light gas moves upward and the heavy downward.

The operation of the apparatus is illustrated by the following experimental results. The object of these experiments was to determine the most efficient design of instrument and not the separation of large quantities of material. The tubes were all one meter in length and the outside diameter of the inner cylinder was 1 cm. A 50–50 mixture of methane and ammonia was used, because analysis could be made quickly by freezing out the ammonia with liquid air. The effect of wall

[1] Chapman and Dootson, *Phil. Mag.*, 34: 248, 1917.
[2] Clusius and Dickel, *Naturwiss.*, 26: 546, 1938.
[3] Brewer and Bramley, *Phys. Rev.*, 55: 590 (A), 1939; Bramley and Brewer, *Am. Chem. Soc. Abs.*, Baltimore meeting, April, 1939.
[4] Mulliken and Harkins, *Jour. Am. Chem. Soc.*, 44: 37, 1922.

clearance was studied in a series of tubes in which the distance between the walls was varied from 1.3 mm to 22.0 mm. The gas separation (ratio of ammonia to methane) rose sharply with increasing wall clearance to a rather broad maximum at 7 mm. The effect of gas pressure was investigated from 11 to 60 cm of Hg for the different tubes. The 7 mm tube gave a maximum gas separation of 27 per cent. at 20 cm pressure. The pressure however is not critical nor is the optimum pressure the same for all gas mixtures. In these tests the temperature difference between the walls was 350° and the average temperature of the gas close to 150°. By varying the power input it was found that the final gas separation increased with the temperature difference between the walls. The rate of separation was investigated for a wall clearance of 7 mm and a temperature difference of 350°. The separation rose to 90 per cent. of its final value in 15 minutes. The absolute rate at which gas could be removed without decreasing the separation factor was not determined with accuracy; it was observed, however, that 1 cc of gas (N. T. P.) could be removed every 15 minutes without influencing the percentage separation. This speed suggests that a continuous flow method of operation should be feasible.

A number of gas mixtures have been studied in addition to the one mentioned above. The operation of the tube can be shown in a striking manner with a uniform 50–50 mixture of helium and bromine. In the course of a few minutes the bromine completely disappears from the top of the tube and becomes concentrated at the bottom. The separation of isotopes is easily demonstrated with HCl, in which gas the ratio of Cl^{35} to Cl^{37} was changed at a pressure of 20 cm from 3.2, its normal value, to 2.8 in a few minutes. The optimum conditions of operation depend, of course, on the nature of the gas. The results obtained with different gas mixtures lead to the conclusion that the separation depends primarily on the difference in mass of the two components divided by their sum.

Experiments have been performed which throw additional light on the mechanism of operation. When the entire tube was inclined 13° from the vertical the separation was decreased from 27 per cent. to 5 per cent. In another apparatus a series of corrugations was placed every 3 cm along the inner tube in such a manner that any gas moving along the heated wall would be deflected into the intervening space. In a 50–50 methane-ammonia mixture the average temperature of the gas was reduced about 15° and the final separation enhanced about 4 per cent. The design of the tube also appears to have a marked effect on the gas separation. A tube was built along the lines described by Clusius and Dickel with a heated tungsten wire extending down the center and a 7 mm clearance. After a run of several hours a smaller final separation of the chlorine isotope was observed with an 800° difference in temperature than was obtained in 15 minutes with the concentric glass tubes for a 350° difference in temperature. A 350° difference in temperature gave only a negligible separation. A similar tube with a 4 mm platinum ribbon down the center failed to show an appreciable separation. It is evident that separation is augmented by symmetry of the two surfaces. An all-glass apparatus in which the outer wall was heated and the inner cooled gave a separation value only slightly lower than when the inner wall was heated; the average temperature of the gas, however, was materially higher.

The rate of mixing of the separated gases has been investigated for various tubes. The results show that the rate of back diffusion increases with wall clearance and becomes very rapid for outside tubes of larger diameter.

Reviewing the above results as a whole, it is evident that conditions involving both wall symmetry and corrugations enhance swirl definition and thereby enhance separation. On the other hand, separation is materially lower in straight wire or ribbon-centered tubes as well as in tubes having small wall clearances in which swirls are either poorly defined or impossible. It appears that the mechanism of separation is different in the two cases. Under conditions where swirls are well defined the separation results from the combined action of initial and thermal diffusion within the swirls. In wire-centered tubes or glass tubes with small wall clearances where the swirls are poorly defined, the mechanism may involve thermal diffusion and an overall convection current.

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